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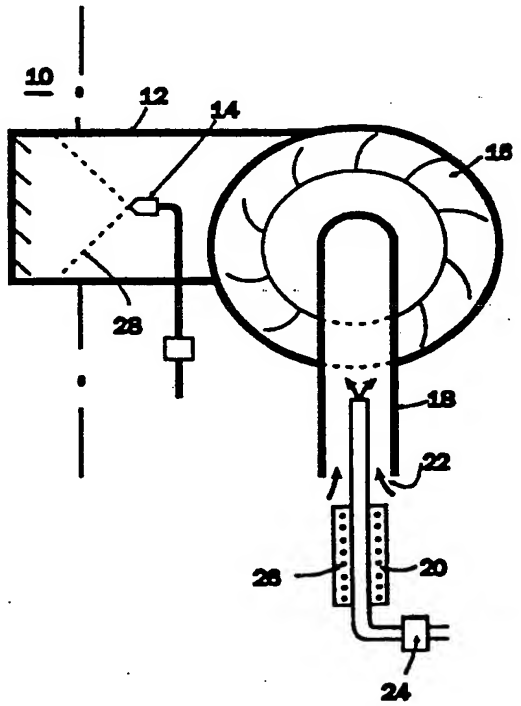
(54) Title: A METHOD AND APPARATUS FOR BURNING LIQUID FUEL IN THE PRESENCE OF WATER

(57) Abstract

A method of burning liquid fuel in the presence of water, wherein a mixture of combustion air and steam is delivered to a combustion chamber through an inlet passage. Water in a quantity predetermined in relation to the amount of air is vapourized, superheated and mixed with the combustion air in a manner such that the relative humidity in the inlet passage will preferably be about 90 %, by preventing condensation of the steam prior to its contact with the fuel.



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A Method and Apparatus for Burning Liquid Fuel in the Presence of Water

The invention relates to a method of burning liquid fuel in the presence of water, in which a mixture of combustion air and steam is delivered to an inlet passage of a combustion chamber.

Methods of this kind have long been known, such as methods of injecting water or steam, or a fuel/water emulsion into the combustion chamber. The water and fuel are normally delivered simultaneously into the combustion chamber, or at a location immediately upstream of the combustion chamber. The effect desired is one of obtaining partial disintegration of the water in the presence of the fuel. When these products of disintegration rejoin after the combustion process, the products will react with intermediate products deriving from the process of combustion. This results in a saving in fuel and also in cleaner flue gases.

However, the result desired is often only achieved to a limited extent, because the water or the condensed vapour droplets are unable to mix with the finely-divided fuel droplets with sufficient thoroughness, meaning that a larger or smaller quantity of liquid droplets are either mixed with too much water or remain unmixed, which, in turn, means that the desired reactions are not obtained to the high extent desired.

One relevant example of the present standpoint of techniques with regard to the present invention is found described in DE-3,614,243 A1. This published specification relates to a method of burning hydrocarbon substances with combustion air, in which the air of

combustion is enriched with moisture (steam), and becomes saturated or oversaturated and is not mixed with the fuel until immediately before the combustion process.

According to this known method, the use of liquid fuels affords the additional advantage that the moist combustion air, when oversaturated with moisture or steam, will contain a finely-divided or atomized mist of water droplets on which the liquid fuel is intended to uniformly distribute.

One drawback with this known method, however, is that the mist of minute water droplets shall be mixed with fuel droplets, wherein the ratio between the weight of the water in respective fuel droplets and the weight of the fuel droplets will vary, since the water droplets, of necessity, will meet the fuel droplets in a relatively arbitrary fashion. Another drawback is that all of these water droplets require energy upon entry to the combustion zone in order to vapourize, and thereby disturb the combustion process.

Accordingly, the object of the present invention is to obtain a constant ratio between the water present on the fuel droplets and the actual fuel droplets themselves to the best possible extent, so as thereby to obtain improved combustion, and to supply the water in a manner such as to prevent cooling of the combustion process to the best possible extent.

The present invention is based on the understanding that a considerably improved water supply can be achieved when the steam is prevented from condensing prior to its contact with the fuel, by admixing the air of combustion with superheated steam, therewith controlling supply so

that the superheated steam and the water in vapour form respectively generate in the inlet passage a relative humidity which is lower than 100%, preferably about 90%. Extremely finely-divided fuel droplets are then sprayed into the intimate gas mixture, these fuel droplets normally having a temperature which lies in the vicinity of room temperature. When these relatively cold fuel droplets come into contact with the superheated steam, the steam is condensed to water on the fuel droplets, wherewith essentially all fuel droplets are supplied with essentially the same amount of water, through condensation.

The condensation heat released will raise the temperature of the fuel droplets, which restricts the quantity of water that can precipitate onto each individual droplet. This temperature increase may reach the flash point of the fuel, which further benefits the combustion process. The amount of water precipitated is controlled by the relative humidity of the combustion air and also by the respective temperatures of the steam and the fuel.

Water in the form of steam and water in the form of condensation on the fuel droplets enters the combustion zone. However, these droplets already contain the amount of energy required to vapourize the water, thereby avoiding undesired cooling of the combustion process, to the best extent possible.

Water is metered to the vaporizer relatively accurately with the aid of a metering valve, so as not to obtain too little steam or too much steam. The correct amounts of water and steam respectively for carrying out the inventive method can be readily obtained in practice and subsequently sustained.

The vaporizer can be heated with the aid of exhaust heat, in a known manner. For instance, when starting an oil burner the burner must be allowed to operate with a steam deficiency over a given period of time, until the exhaust heat is sufficiently high to heat the vaporizer to the temperature desired. In order to avoid delay in the commencement of steam generation and therewith consequent impaired combustion during the starting-up period, electric heating is employed in accordance with the invention, therewith heating the evaporizer much more rapidly.

The main characteristic features of the inventive method are set forth in the characterizing clause of the following Claim 1.

An oil burner which operates in accordance with the principles of the invention is illustrated schematically in the accompanying drawings, in which

Figure 1 illustrates the oil burner;

Figure 2 illustrates a modified steam generator; and

Figure 3 illustrates a metering valve.

The burner illustrated in Figure 1 includes a combustion chamber 10 into which a burner pipe 12 extends. The burner pipe 12 has arranged therein a fuel nozzle 14 for the injection of fuel in the form of extremely finely-divided fuel-droplets in the fuel pipe, which is included in the inlet passage to the combustion chamber.

Connected to the burner pipe is a fan 16 which receives air from an inlet pipe 18, in a known manner. A vaporizer 20, discharges into the inlet pipe and an inflow gap

22 for the inflowing of air is provided between the end of the vaporizer pipe and the inlet pipe 18.

Water is led to the vaporizer through a metering valve 24. In the illustrated example, the vaporizer is heated with an electric heating device 26.

The water is converted to steam in the vapourizer 20, this steam being superheated to a temperature above 200°C, preferably about 400°C.

The superheated steam is mixed with the air flowing in through the gap 22 and steam and air are further mixed together in the fan. The process is controlled so that the combustion air will have a relative humidity of less than 100%, preferably about 90%, downstream of the fan but upstream of the fuel nozzle.

The finely-divided fuel droplets form a conical configuration 28 downstream of the nozzle 14, and when the steam meets the finely-divided fuel droplets, the steam will condense on the relatively cold fuel droplets.

Alternatively, the superheated steam can be delivered to the region between fan 16 and nozzle 14.

Figure 2 illustrates schematically a modified steam generator.

In the case of large systems requiring large quantities of steam, there is needed a steam generator of the kind described below. A constant water level 32 is maintained in the container 30. The water is heated to boiling point by the element rods 34. The steam leaves the vapourizer through the pipe 26. This pipe has mounted therein an element rod 38 which superheats the steam. By

incorporating the superheater in the vapourizer, heat losses are reduced and no external part of the steam generator, with the exception of the outlet pipe, is maintained at a higher temperature than 100 degrees.

Figure 3 illustrates a suitable metering valve. When metering small quantities of liquid, such as water, throttling of the flow is an unsuitable method, due to the contaminants that can occur. It is also difficult to achieve metering of the liquid with the aid of a valve which alternates between an open and a closed position. The valve shall be opened, the current switched-off so that the magnetic field ceases to exist, and the valve shall be closed. Liquid is able to pass during the course of these events.

According to the invention, there is used instead a valve which alternates between a closed and a closed position. Very little water is able to pass at the moment of switching the valve between these positions.

A coil 42 is mounted in the valve housing 40. The core 44 is pressed against the valve seat 48 by means of the spring 46 and therewith closes the outlet 50. When current is applied to the coil, the core 44 is urged against the valve seat 52 and closes the inlet 54. When the current is switched-off, the core returns and again closes the outlet. Very little liquid is able to pass through the valve during this extremely short valve-switching time. The amount of liquid that passes through the valve is adjusted by controlling the timing at which the valve is switched between said positions.

Various embodiments of the valve are possible within the scope of the invention. For instance, the ends of the valve core can be made resilient, so as to avoid impact

with the valve seat. Instead of the valve core being moveable in the direction of its axis, the core may have the form of a hinged plate which flips between its respective positions.

Claims

1. A method of combusting liquid fuel in the presence of water, comprising delivering a mixture of combustion air and steam to a combustion-chamber inlet passage, c h a r a c t e r i z e d by preventing condensation of the steam prior to its contact with the fuel by vapourizing a predetermined quantity of water in relation to the quantity of air, superheating the water vapour and mixing the superheated water vapour with combustion air in a manner such that the relative humidity in the inlet passage will be less than 100%, preferably about 90%.

2. A method according to Claim 1, c h a r a c t e r i z e d by superheating the water vapour to at least 200°C, preferably at least 300°C, suitable about 400°C.

3. A method according to Claim 1, c h a r a c t e r i z e d by heating the fuel droplets to a temperature above the flash point of the fuel by means of the heat of vapourization released upon condensation of the steam.

4. Apparatus for carrying out the method according to Claim 1 or Claim 2 in oil burners which operate with alternating active and inactive periods, c h a r a c t e r i z e d by vapourizing and heating the water in an electrically heated vapourizer.

5. Apparatus according to Claim 4, c h a r a c t e r i z e d in that the vapourizer (30) is constructed so that the steam will exit through a pipe (36) within the vapourizer (30) which includes heating elements (38) for superheating the steam.

6. A metering valve in the form of a solenoid valve for use when carrying out the method according to any one of Claims 1-3, c h a r a c t e r i z e d in that the valve is intended to alternate between two closed positions; and in that water is permitted to pass solely during the extremely short period of time when the valve is switched from the one closed state to the other.

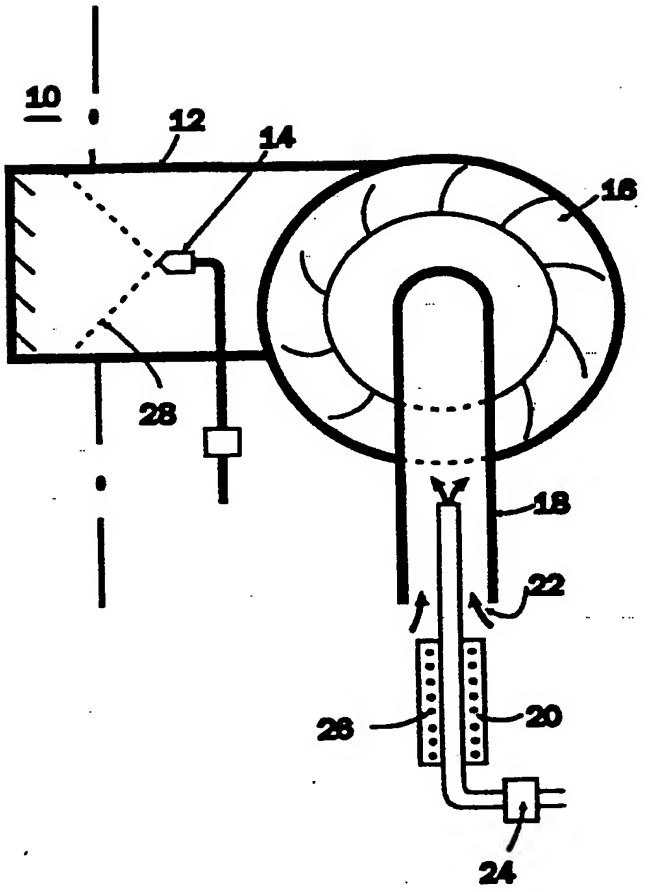


Fig.1

Fig.2

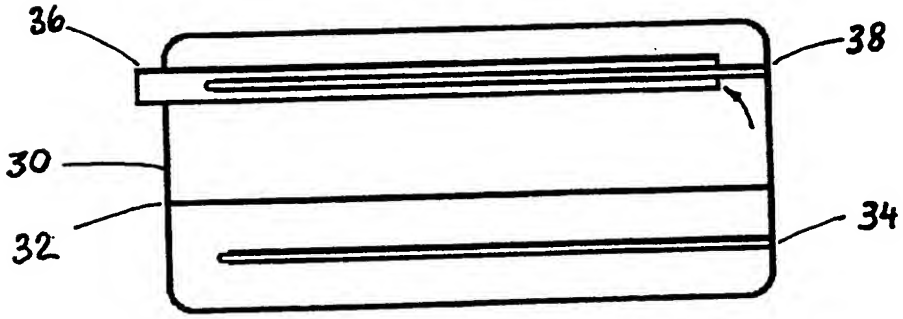
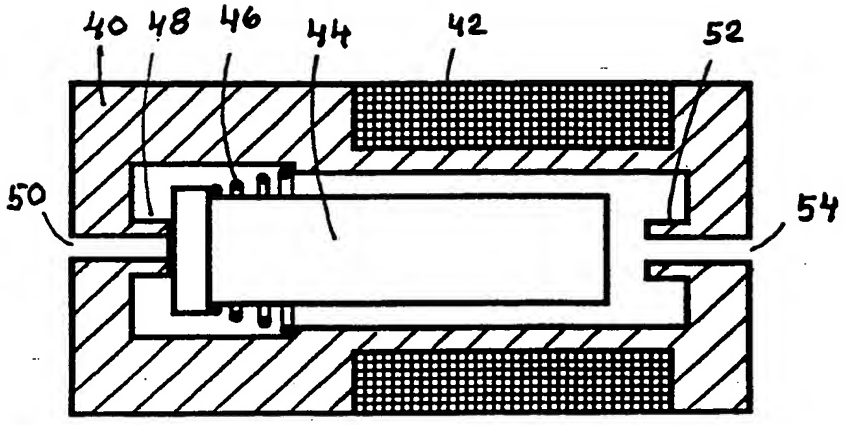


Fig. 3



INTERNATIONAL SEARCH REPORT

International Application No PCT/SE 92/00488

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC5: F 23 L 7/00

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
IPC5	F 23 L; F 02 M

Documentation Searched other than Minimum Documentation to the Extent that such Documents are included in Fields Searched[8]

SE,DK,FI,NO classes as above

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category *	Citation of Document,[11] with indication, where appropriate, of the relevant passages[12]	Relevant to Claim No.[13]
A	DE, A1, 3614243 (WITTEK, FRANZ X.) 29 October 1987, see column 5, line 7 - line 55 --	1-5

* Special categories of cited documents: [10]

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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
20th November 1992	23 -11- 1992
International Searching Authority	**Signature of Authorized Officer**
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ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO. PCT/SE 92/00488

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
The members are as contained in the Swedish Patent Office EDP file on 30/09/92
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DE-A1- 3614243	87-10-29	NONE	